NASA Phase II Project Summary

NONPROPRIETARY

Firm: Creare Incorporated
Contract Number: NNX11CB45C
Project Title: Nonventing Thermal and Humidity Control for EVA Suits

Identification and Significance of Innovation:

Future manned space exploration missions will need space suits with capabilities beyond the current state of the art. Portable Life Support Systems (PLSSs) for these future space suits are extremely challenging, since they must maintain healthy and comfortable conditions inside the suit for long-duration missions while minimizing both weight and venting of consumables.

This project builds on the results of two successful, prior contracts in which Creare developed a Lithium Chloride Absorber Radiator (LCAR) to enable nonventing thermal control of exploration space suits. The LCAR enables heat rejection from space suits without venting significant amounts of water. The current project had two technical objectives: (1) development of an innovative heat acquisition system—an evaporative cooling and dehumidification garment (ECDG)—that absorbs sensible and latent heat from inside the space suit pressure garment and couples to the LCAR for heat rejection, and (2) development of a flat-panel LCAR that will simplify integration with the portable life support system. The ECDG, coupled with the LCAR, enables an innovative system for temperature and humidity control in a space suit that promises to be simple, rugged, lightweight, and nonventing.

Technical Objectives and Work Plan:

The overall goal of Phase II was to build a prototype ECDG and a prototype flat-panel LCAR and show that they achieve these objectives. The specific technical objectives for the ECDG were to: (1) provide cooling at typical metabolic rates, (2) provide cooling without the need to vent water from the space suit, (3) use materials that are compatible with the low-pressure oxygen environment inside a space suit pressure garment, (4) produce a garment that is conformable and flexible enough to remain in good contact with the user during operation, (5) provide both sensible and latent cooling, (6) produce thermal performance map for the prototype garment, and (7) ensure that the ECDG can be integrated with current designs for future space suits. The goals for the flat-panel LCAR were to: (1) demonstrate that high heat absorbing capacity could be achieved in a very thin panel, and (2) demonstrate that improved internal flow features could provide a highly uniform radiating panel temperature.

To achieve these objectives for the ECDG, we developed fabrication methods for the ECDG, built laboratory test facilities, and performed extensive laboratory testing to measure performance of ECDG prototypes using sweating hot plate tests in a low-pressure chamber. To demonstrate performance of the advanced LCAR, we developed fabrication methods, assembled two 1 ft^2 flat-panel LCARs, and measured their performance in thermal vacuum tests that simulated operation during an EVA.

Technical Accomplishments:

We assembled lightweight and flexible ECDG pouches from prototypical materials and measured their performance in a series of separate effects tests under well-controlled, prototypical conditions. Sweating hot plate tests at typical space suit pressures show that ECDG pouches can absorb sensible and latent heat at rates that are high enough for use in future space suits. These results are in good agreement with the predictions of our analysis models.

The flat-panel LCAR was designed to maintain uniform vapor flow throughout the entire panel. The prototype unit was only 0.5 in. thick, and the dry weight of each 1 ft^2 panel was 1.6 kg. Each panel was capable of absorbing 0.24 kg of water. The proof-of-process panels were tested in the thermal vacuum chamber, where they radiated heat to an LN2-cooled shroud. The panels demonstrated a heat rejection flux of 35 to 45 W/ft^2 and a heat absorbing capacity of 167 $W\text{-}hr/ft^2$, which scales up to 250 $W\text{-}hr/ft^2$ in future designs with advanced fabrication methods. Panel temperatures uniform to within +/- 5.6°C. Panel regeneration at 120°C took 4 hours. We used these data to project the performance of advanced LCARs in future space suit life support systems.

NASA Application(s):

The proposed system can be used in any future space suit, with applications that include lunar and Mars exploration or constructing/servicing next-generation space telescopes while maintaining a clean environment. The basic technology can also be used to provide rugged, nonventing thermal and humidity control for spacecraft, manned rovers, and habitats.

Non-NASA Commercial Application(s):

There are numerous commercial and military applications for the proposed technology. Commercial applications include untethered personal cooling systems for law enforcement, nuclear/chemical plant workers, and heat-sensitive multiple sclerosis patients. Military applications include personal cooling systems for soldiers or marines wearing chem/bio protective gear, body armor, EOD suits, or level-A HAZMAT suits.

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